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ABSTRACT

This study examined issues that arose during the development and implementation of a modified form of traditional problem based learning (PBL) at one Canadian university. It explored PBL in the context of preservice education, investigating how it could be used to foster an inquiry based approach to preservice preparation and how preservice teachers perceived PBL as a means of learning. The study focused on a 3-credit-hour undergraduate education methods course, Advanced Studies in Science Education. PBL groups met over 12 weeks, addressing pedagogical problems that focused on some aspect of science teaching and learning. At the end of the course, each PBL group delivered a workshop based on a solution to the pedagogical problem. Participating students completed surveys and interviews about their experiences. Results suggested that using modified PBL with large groups was challenging because of the difficulty in ensuring that groups functioned effectively. However, it encouraged students to explore problems, examine their complexity, and find practical ways to address them in the context of the classroom. Students felt that they learned about science teaching in the workshops, though they believed the amount of learning depended on the quality of the workshop and the nature of the activities involved. (Contains 21 references.) (SM)

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Problem-Based Learning Special Interest Group

Issues in Modified Problem-Based Learning: A Study in Pre-service Teacher Education

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Introduction

> I like this approach; we were given a problem and time to do it. You provided us with support and feedback, but it was still our problem. I liked that we could approach it the way we wanted to. . . . You did not talk at us and we had an opportunity to present in front of our peers. (Pre-service student, April 2002)

These comments reflect the perceptions of one of my pre-service students after participating in a Problem-Based Learning (PBL) experience in an advanced undergraduate science methods course. The student enjoyed learning through PBL (although not all of my students did), and her comments highlight what she found desirable about the approach– examining an issue by starting with a problem, establishing ownership of the problem, developing autonomous learning, and sharing learning with the professor and other classmates. Many of these ideas are consistent with my personal beliefs about how to best prepare pre-service students for the demanding world of teaching. The pedagogy I adopt when implementing courses reflects a belief system that aligns with constructivism, an eclectic perspective on learning that focuses on both the individual and social construction of knowledge (Piaget, 1977; van Glasersfeld, 1995). When applying this epistemological view to learning, the use of only transmission models of learning (Miller & Seller, 1990) do not suffice. Educators who hold a constructivist perspective structure learning experiences that allow students to construct their understanding of phenomena based on prior knowledge, learning styles, and developing perceptions. Students need to have opportunities to explore and reflect upon their ideas and how they fit with new ideas, and to question and share their thinking in a social context.

PBL is consistent with my current belief system and practice, reflecting a constructivist referent for teacher preparation. Furthermore, these beliefs align with how many other educators have attempted to reform teacher education (see Franks, 1994; Fried, 2000; Onslow & Laine, 2000; Sage, 2000). Graduates of teacher education programs need to have the necessary skills, attitudes, and dispositions to deal with the complexities of the present-day classroom. The increasing diversity of student groups, the movement towards the creation of inclusive classrooms, and the ongoing emergence of new technologies are some factors that present a myriad of challenges to beginning teachers (Dean, 1998). Without developing the skills to

become life-long learners and an inquiry-based approach to teaching, beginning teachers will be ill-prepared to deal with the realities of the classroom.

Reform in teacher education implies a willingness by faculty to embrace innovative approaches to teaching and learning and to engage in group and individual research and reflection about how to best improve their teaching. Faculty must develop their understanding of new teaching and learning approaches and how to effectively implement them in their courses. As a faulty member primarily responsible for the preparation of middle and high school science teachers, I designed this study to explore a student-centered learning approach referred to as PBL. More specifically, through action research and individual reflection, I wanted to gain a more in-depth understanding of how to plan and implement PBL in the context of large pre-service education classes. This paper will focus primarily on the issues and concerns that arose as I developed and implemented a modified form of traditional PBL (Barrows, 1996).

The Nature of PBL

The origin of PBL can be traced to the work of Dewey (1944) who emphasized the connections amongst doing, thinking, and learning. Learning, according to Dewey, "should give students something to do . . .and the doing is of such a nature as to demand thinking or intentional connections" (1944, p. 154). PBL not only provides a tool for fostering thinking and active learning, it is also an instructional approach that has the potential to support many of the tenets of constructivist learning theories–learners actively construct knowledge through interactions with the environment and social negotiation (Savery & Duffy, 1995).

As an explicit approach to learning, the original model for PBL was developed at McMaster University's medical school by Howard Barrows. In adopting this approach, Barrows hoped to develop medical students' content knowledge and their ability to use that knowledge to address health care problems and "to provide appropriate care for future problems [students] . . . must face" (Barrows, 1985, p.3). In the medical model, learning is student-centered and occurs in small groups, teachers act as facilitators or guides, problems are the organizing theme for learning, problems are the means for the development of clinical problem-solving skills, and new understanding occurs through self-directed learning (Barrows, 1996). In the modified PBL

adopted in this study, most of these characteristics were present–learning occurred in small groups of three to four, I acted as a facilitator, learning was student-centered, and there was an emphasis on the development of content knowledge and problem-solving skills. However, each group of PBL students did not have a tutor as in the original model. Rather, each group tackled a different problem, working independently for most of the time. I was the facilitator for all groups.

Since the inception of the original PBL model, other variations have arisen in contexts outside the medical school. Although recent meta-analyses have focussed primarily on the outcomes of PBL instruction (Albanese & Mitchell, 1993; Vernon & Blake, 1993), little research has explored issues of process. Hence, this study focusses on issues of process in planning for and using PBL as an instructional approach. Without an understanding of how modified PBL formats are implemented and the conditions under which they may be effective, little can be garnered about the merit of PBL in pre-service teacher education.

The Research Questions

This study focussed on an exploration of PBL in the context of pre-service science education. The research questions I addressed were: (a) How can PBL be used to foster an inquiry-based approach to pre-service preparation? (b) How will students perceive PBL as a means of learning? and, (c) What challenges will I encounter when developing and implementing PBL curriculum? The latter question is the focus of this paper.

The Class and Course

The first iteration of this study was conducted in the Winter semester of 2002. Thirty-three pre-service students were enrolled in an advanced three-credit hour undergraduate education methods course, *Advanced Studies in Science Education*, a mandatory component of a sixty-credit hour program that results in certification to teach middle school or high school science in Canadian schools. Most of the students were in a consecutive program, having entered the program after completing a Bachelor of Science, while five were in a concurrent program, completing a Bachelor of Science and Bachelor of Education simultaneously. Students ranged in age from 21 to 40 years, while the class was balanced in terms of gender. Upon program

commencement, most had limited teaching experience in K-12 settings. At the end of this course, students were expected to: a) demonstrate, by participation in classroom seminars and activities, an in-depth knowledge and understanding of the discipline of science, b) analyse possible problem situations and challenges that may arise in the context of science teaching, c) implement instructional and assessment strategies to foster scientific literacy, d) describe strategies for implementing an STS (science-technology-society) emphasis in a science classroom, e) identify the safety precautions teachers should consider at the beginning of the school year, f) explain the role of the teacher in developing and implementing science curriculum, g) reflect on their developing beliefs about the nature of science, and h) examine the role of practical work in learning science. The course builds on ideas and concepts introduced in an introductory course completed by students in the Fall semester of the program.

The group met for twelve weeks on Tuesdays and Thursdays for 80 minutes each day. On Tuesdays for the first seven weeks, I engaged students in a range of learning activities such as lectures, case studies, web-based learning activities, whole-group and small-group discussions and investigations, and seminars designed to emphasize learning outcomes, pedagogy, methodology, and content. During the Thursday sessions in the first seven weeks, students worked in collaborative PBL groups of four or five to address a pedagogical problem focussed on some aspect of science teaching and learning. Appendix A provides examples of some of the problems used in the course. Groups were assigned different problems, after being asked to rank their top three issues from a list: integrating curriculum, scientific inquiry, cooperative learning, equity and science, curriculum differentiation, portfolio assessment, multiple intelligences theory, and learning styles.

In the last five weeks of the course, each PBL group was responsible for delivering an 80-minute workshop based on a solution to the pedagogical problem. The planning and delivery of the workshop was assigned a grade. In addition, each group was required to create a product that illustrated their understanding of the issues raised in the problem. In terms of individual assessment, each student completed a PBL journal that was a record of his or her thinking about the PBL process and a peer-evaluation of how individuals contributed to the overall effectiveness of the group. Approximately two-thirds of the course was devoted to PBL.

Methodology

Of the 33 students who enrolled in the course, 28 decided to participate in the study. When research is conducted with one's own students, issues of power become paramount. I adopted principles premised on openness and fairness; I assured students that their participation or nonparticipation in the study would not affect their academic performance. Data, over and above normal course requirements, were collected after the submission of final grades.

In studying my own practice, I adopted classroom-based action research (Kemmis & McTaggart, 2000) as a strategy to explore PBL. I engaged in self-reflective spirals of "planning, acting, observing and reflecting, with each of these activities being systematically and self-critically implemented and interrelated" (Grundy, 1982, p. 23).

To enhance the trustworthiness of the study (Guba, 1981), I adopted many of Wolcott's principles (Wolcott, 1990) such as listening extensively, recording observations accurately, writing early, reporting fully, being candid, using primary data when reporting, obtaining feedback from others, and writing accurately. Furthermore, to view the research from many perspectives, I used a variety of data collection methods and sources. Field notes were recorded, during and after classes, describing classroom events and my interpretation of those events. Student-generated documents, a personal technology that requires contextualized interpretation (Hodder,2000), served as another sourse of data. Students' workshop plans, group products, and individual journals were analysed to enhance data analysis and interpretation. Informal conversational interviews (Patton, 1990) occurred with students during and after scheduled class sessions, while semi-structured interviews were conducted with seven student volunteers at the end of the course. In addition, at the end of the course, I asked a colleague, an experienced user of PBL, to interview me about my experiences in using PBL as an instructional approach. This interview fostered self-reflection, became a learning opportunity as we shared our ideas about PBL, and served as a source of data.

All interviews were audiotaped and later transcribed; careful notes were taken after each interview. An open-ended written questionnaire, administered at the end of the course, asked students to respond to probing questions about their perceptions of many aspects of PBL and what they learned through participation in the PBL experience. These surveys, completed when I

was not in the class, were stored in the Dean's office until after my course grades had been submitted.

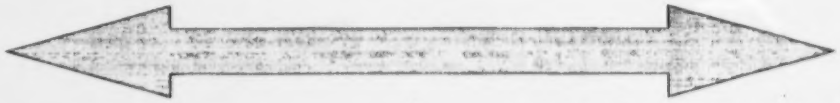
Throughout the study, data analysis coincided with data collection. According to Marshall and Rossman (1999), "data analysis is the process of bringing order, structure, and interpretation to the mass of data collected" (p. 150). In analyzing the data, I used grounded theory (Strauss & Corbin, 1998), beginning with open coding to identify concepts. I assigned labels to units of text from transcripts, field notes, journal entries, and interviews, forming the basis for identifying concepts throughout the data set. Simultaneously, I engaged in constant comparison, identifying similar incidents and events for grouping into the same conceptual categories. I then used axial coding, generating main categories and subcategories, to establish larger categories and make connections among larger categories and subcategories.

Results/Discussion

The process I adopted when developing and implementing PBL is outlined in Figure 1. Issues and challenges arose at all stages of curriculum development and implementation. Subsequently, I describe the challenges I encountered, including how my understanding of PBL and my classroom practice changed as a result of this experience.

Planning for PBL. My initial interest in PBL started about three years ago through participation in an outreach educational project (K-12 teachers and students) sponsored by a medical school. After considerable reading about PBL, it soon became clear that if I were to adopt PBL as an instructional approach in pre-service teacher education, it would not require a monumental shift in my thinking. My classes already reflected variety in instruction and assessment, the modeling of instructional approaches that could be used with K-12 students, and a focus on encouraging students to engage in both individual and group reflection.

Before implementing PBL in my course, I met with a group of social studies educators in my faculty who have been using PBL for several years. Their PBL model aligns with the Barrows model, using tutors to facilitate self-directed learning within small groups. My first concerns emerged after a series of discussions with my colleagues. I could not use tutors in my large pre-



Curriculum Development

Professor:

- Choose/develop a relevant problem
- Identify concepts and learning outcomes (create a concept map)
- Anticipate student questions
- Select resources
- Develop a timeline
- Select assessment and learning activities
- Develop a plan for implementation
- Consider group formation/functioning issues

Curriculum Implementation

Students:

- Greet the problem
- Define the problem
- Identify what they know, what they need to know, and how they will answer their questions
- Gather information and resources
- Determine a best solution
- Present solution
- Debrief the problem

Figure 1. The process I adopted when designing and implementing PBL curriculum

service class, so I reflected on how I would ensure that each PBL group received the appropriate support and feedback To address this concern, I met with each of the nine groups for at least five to ten minutes during each PBL session. Each group was required to keep a log after each meeting, outlining what was discussed and what was agreed upon by the group. Through this logging process, group members would have clear expectations for what they were expected to do between meetings. I checked logs periodically to monitor how groups were progressing, and I repeatedly encouraged individuals and groups to seek my input after class or through out-of-class scheduled sessions if they needed additional support.

In structuring the PBLs, I had to re-examine my course goals and learning outcomes and identify topics that I wanted to explore through PBL. After doing this, then came the challenging task of designing authentic, open-ended problems that would reflect the complex reality of science teaching. This required considerable thought, using a myriad of resources and my own

personal experiences as a K-12 teacher and teacher educator. Because PBL group members were highly motivated and strong students academically, the pedagogical problems were open-ended. I did not provide any resources at the outset, although I did offer suggestions for locating specific materials and resources as the need arose during facilitation.

When examining the time line for the course, the amount of emphasis placed on PBL had to be determined. Between time devoted to PBL group sessions and the implementation of student workshops, approximately 60% of course time was dedicated to addressing the PBL pedagogical problems. In retrospect, this was a huge undertaking for a new teacher of PBL and somewhat ambitious.

Another concern focused on the nature of the groups. Ultimately, I chose to group students randomly with the exception of having gender balance within each group. My assumption was that students already possessed many of the skills necessary to function successfully in groups. Unfortunately, I should not have made this assumption, as all groups did not function as well as I had anticipated.

Assessment is another area of the PBL process that requires careful planning. The use of authentic forms of assessment is an integral part of PBL. Consequently, I asked each PBL group to create a product of choice (e.g website, brochure, lesson plan) and to conduct a workshop as a means to debrief and share the outcomes of the PBL.

Facilitation. Based on my experience, I believe one of the biggest challenges in the use of modified PBL for large classes is facilitation. The professor has to find a variety of ways to monitor the functioning of each group because she is often unable to spend large amounts of time with any one group. Based on my observations of groups and feedback from groups during class meetings, I felt most groups functioned fairly equitably. There was sharing of ideas, role differentiation within each group, and equity in terms of workload. It was a surprise, at the end of the process when I was reading journals, to discover that one group had not functioned well. "Although I like PBL, my group fell apart at the end. This became the least enjoyable group experience ever" (Journal comments, pre-service student). Although the final product created by this group was high in quality and presented a very feasible solution to the problem, the group struggled with reaching a consensus on the content and format of the final product. Despite my

efforts to encourage groups to seek my support and help if group dynamics problems arose, this group did not avail of this offer.

During PBL class meetings, I assumed a variety of roles. Sometimes I was simply a sounding board for groups' developing ideas, while at other times I provided guidance for product and workshop design. In terms of the content of the problems, I tried not to be too directive, allowing group members to generate their own ideas and, at times, to struggle with developing understandings. It was often tempting to provide concrete suggestions to groups about how to solve a problem. Providing the optimal amount of scaffolding to groups is always a concern for the facilitator.

Nature of the problem. "One thing I have to look at more carefully is the nature of the problems. I am not sure all my problems were engaging. The other thing I discovered was that the problems varied in complexity; some were far more challenging than others" (Interview, April 2002). I shared these comments with a colleague during an interview about my post-PBL reflections. Throughout the process, as I facilitated, some groups struggled with their problem for longer periods of time than others. All problems were multi-faceted; however, some were extremely open-ended and introduced a range of subproblems within the larger problem. With the more complex problems, groups spent more time and energy defining the problem, exploring the issues raised by the problem, and locating resources. For example, about 42% of the groups reported that they had too much time to complete the problem. Several students felt they could have addressed two problems in the time frame I provided. In contrast, 50% of students indicated they had adequate time to address the problem. I believe this reflects variability in terms of the demands of each problem, thus some groups needed less time to explore issues and create a solution. Having too much time can result in a lack of motivation and engagement in a PBL experience. This is resonated in one student's comments: "The advantage in this [completing two PBLs] would have been that we would have been more motivated and ready to start another activity right away" (Pre-service student, Interview, April 2002).

Another issue related to PBL problems that concerned me was some students' inability to see the connection between the problem and science teaching and learning. For example, at least five students felt that the topic was too broad and not specific enough to science teaching. One

student commented that the use of portfolios was "not very relevant to science" while another student said, "This problem was completely irrelevant to teaching science." This inability to make explicit connections to science teaching and learning may suggest that the problems need to be more embedded in classroom practice, with assessment that allows students to integrate science content and pedagogy more closely.

Workshops. The workshops provided a forum for each PBL group to share what it learned about their problem, an opportunity for me to assess students' understanding of the issues raised by the problem, and a platform for students to use a range of presentation and communication skills. Although I judged all workshops to be well-developed in terms of content and the exploration of issues (grades ranged from a B+ to an A+), four of the seven presentations lacked significant variety in terms of workshop learning activities; there was a heavy reliance on lecture and PowerPoint presentations. Furthermore, students did not build enough time into the process for debriefing and feedback. This is a future concern that I will address by allotting more time to debrief the problem in small groups and providing more direction to students about how to conduct an interactive, engaging workshop. Although a rubric was provided outlining my expectations for the workshop, it is clear that students need more guidance in this area.

In responding to a question about the merit of the workshops, ninety percent of students reported that they were learning about science teaching from the workshops. However, they said the amount of learning depended on the quality of the workshop and the nature of the activities used during the workshop. Once again, more specific direction from me about how to design and implement an effective workshop may address this concern. The three students who felt they were not learning from the workshops thought the presentations were boring, and would have preferred to explore each of the topics in more depth.

One means to introduce a stronger element of accountability regrading the workshops would have been to ask each student to provide feedback (strengths, areas for improvement) about the content and format of the presentations. This may have also fostered higher interest in the workshops for some students.

Changing Practice

Since completing this study, I have continued to use PBL, making several adjustments and modifications based on what I learned during the first cycle of implementation. I continue to use it in ED4511, the course described in this study, and have also incorporated a small PBL component into an introductory science methods course for elementary pre-service students. In the current course (Winter 2003), I changed the format, requiring all students to complete the same two PBLs, a modification of the approach used previously. In my first use of PBL, each group completed a different problem and offered a workshop at the end. Although it was engaging to have seven different workshops and each group became experts on a topic, students were only able to explore one topic in depth. Both approaches have merit and I may return to the initial approach in which each group completes a different PBL.

To improve the PBL experience for students, in the second iteration of this study, I have modified several aspects of my practice:

Problems-To make the problems more relevant, on the first day of classes, I asked students to share their three biggest concerns about science teaching at this stage in their careers. The top concern, expressed by 95% of students, was classroom management, while the second was how to meet the needs of diverse learners in the science classroom. To address these concerns, I designed one PBL around each topic. By developing problems that reflected students' concerns, I hoped to make the PBL experience more motivating and relevant.

Facilitation-Because of the limited amount of time that can be spent with PBL groups in large classes, I have tried to find ways to elicit more ongoing feedback about what groups are learning and how well each group is functioning. I continue to ask groups to complete a log at the end of each PBL session to clearly delineate what was agreed upon during the meeting and what each group member is expected to do before the next meeting. This explicit clarification of expectations avoids confusion and introduces an element of accountability. In addition, I continue to ask each student to make guided journal entries, and now read and respond to these more frequently as the PBL is ongoing. This provides more frequent feedback, alerting me to potential group dynamics problems earlier in the process. To foster group rapport, another idea I am exploring is to engage groups in some initial community-building activities before starting a

PBL. Groups are sometimes slow in starting because they to not know each other and trust has not yet been established.

In my first implementation of PBL, I did not consider using other instructional approaches to support the use of PBL. In contrast, in this current implementation of PBL, I have periodically used more group debriefings as well as videos and discussions of selected readings. This helped some groups and individuals who seemed to need more direction during the exploration of the problem.

Assessment-This is always a challenge when using any instructional approach that is student-centered. I have continued to require that students create a product to demonstrate learning. In one instance, I specified the product–an annotated bibliography and a CD-ROM or brochure. The second PBL incorporated a product of choice that showed evidence of how to integrate science content, pedagogy, and differentiation strategies. Many students chose to develop lesson plans, while one group designed a newsletter. Although I did not use a workshop format, I did allow time for groups to share their ideas and products in small group settings at the end of each PBL experience. Furthermore, if there were gaps in some aspects of students' learning, I addressed this with the whole group after assessment was complete.

Final Reflections

Using modified PBL with large groups is inherently challenging because of the difficulty in ensuring groups function effectively. In my current ED 4511 class, two of the nine groups are experiencing group functioning problems. Although I encouraged them to involve me when resolving concerns and problems, most are reticent to invest emotions and time in a short-term PBL group to ensure the group functions effectively. Although it would be preferable for each PBL group to have an experienced full-time tutor, in most undergraduate education programs this is not possible. Despite this challenge, I still believe the benefits of PBL outweigh the drawbacks. I will continue to use PBL in ED 4511 and hope to garner more insights based on this self-study. One of my goals has been to foster, in students, an inquiry-based approach to teaching by modeling this in my own teaching. Indeed, I believe I was successful in doing this; students explored problems, examining their complexity and finding practical ways to address the

problems in the context of a classroom. Of course, to determine if this inquiry approach to teaching is translated into classroom practice, it would be necessary to follow these students into their beginning years of teaching.

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Appendix

Sample Problem A:

So, What's So Bad about Competition?

Janice Langdon is a first-year Biology teacher. She would describe her approach to teaching science as highly student-centered and premised on a belief that students learn best when they are actively engaged in their learning. It is early in the year and she has been doing some group work in her classes. To her dismay, she discovers that several problems are arising whenever she attempts to structure collaborative learning experiences. There seems to be incessant arguing, groups are not on-task, and productivity levels are low. She had assumed, after 11-12 years of schooling that her students would be adept at working within teams. In one Level- three Biology class, she decides to use part of the class to explore her concerns and to get feedback from students.

Some of her students share their ideas readily when asked about why they seem to be struggling when they have to work in teams:

> *I am sorry miss. I know you say team work is important, but it takes too much energy and thinking. Just give me the notes and talk and I will learn just as well. (Jim)*
>
> *Miss L. We talked about learning styles in social studies class. I work best on my own. No offence to you guys . . you slow me down. (James)*
>
> *How about our grades? Why should I work like a dog when everyone will not? Why should we all get the same grade? (Sarah)*
>
> *Miss, other teachers do not require us to work in groups. This really sucks! (Joe)*
>
> *I like groups sometimes, Miss Langdon. I would like them better if we could get along and work as a team. (Isha)*

Janice wants to continue with her goal of fostering collaborative team work. However, there are several concerns she needs to address. How can Janice address these concerns? What changes in her classroom practice will be needed?

Sample Problem B:

Equity in the Science Classroom

Context: High School Science Classes-Grade 10

After attending a workshop session on equity in science education at the New Brunswick Teachers' Association provincial high school conference in Moncton, you have become more cognizant of your classroom behaviours.

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After monitoring your behaviour for about two weeks, you discover that students are getting different amounts and types of attention from you, based on their gender. In general, boys are getting more positive and negative attention from you than are girls.

What, if anything, can do you do to change this imbalance?

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